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THE CORRELATION BETWEEN MILK YIELD OF ONE LACTATION AND THAT OF SUCCEEDING LACTATIONS.

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BULLETIN 289

THE CORRELATION BETWEEN MILK YIELD OF ONE LACTATION AND THAT OF SUCCEEDING LACTATIONS.*

By John W. Gowen.

SUMMARY

This bulletin presents a study of the accuracy with which the milk production of one lactation indicates the milk production of a subsequent lactation for a pure bred herd of Jerseys under uniform farm conditions. The correlations describing the relation of one lactation with another lactation range from +0.7306 to +0.2144. The numerical value of such correlation coefficients signifies that with a fair degree of accuracy the milk production of one lactation measures the probable milk production of a subsequent lactation.

The arithmetical equations necessary to determine this probable production are given in table 3.

The relation of the milk production of one lactation with the milk production over five lactations is determined. These correlation coefficients range from +0.8613±.0186 to 0.7416 ±.0323. Such high values indicate that with slight inaccuracy the milk production of one lactation predicts the milk production for the first five lactations.

Data are presented to show that the milk production of one lactation is a better measure of a cow's milk production of another lactation than the egg production of one month is of the egg production for the year.

Table 5 furnishes a ready means of determining from the milk yield of the first lactation (8 months of lactation) what

*This paper is an abstract of a longer paper on "Studies in Milk Secretion VI. On the Variations and Correlations of Butter-Fat Percentage with Age in Jersey Cattle" by the same author published in Genetics, March 1920. All literature citations should be made to this complete paper.

the total milk yield of the first five lactations (8 months lactation periods) will be for a Jersey herd of similar milk production to the herd here studied.

In a previous bulletin the variation of milk yield with age has been determined. In the present paper the phase of the problem dealing with one lactation in its relation to another will be considered.

The functioning of the mammary glands may be considered dependent upon three main factors, taken in order of their position in time, heredity, development through feeding, etc., (environmental circumstances of these organs up to their commencing to secrete) and lastly environmental factors in their widest sense acting during the months when the gland is active. It is reasonably clear that on our ability to distinguish the relative influence of these three basic variables depends many of the common *a priori* dairy practices as well as furnishing a solid foundation for the analysis of the causal mechanism of milk production itself. The analysis is a complex one and needs to be attacked by many channels. The present investigation was undertaken in the hope that by an analysis of the intra individual variation of milk secretion from lactation to lactation some light would be given on the relative merits of these three variables. The homogeneous nature of the material is such, however, that the investigation necessarily deals chiefly with the first of these variables.

Little work on milk secretion has been done that approaches the problem from this viewpoint. Of the available data those on the English herds analyzed by Gavin are undoubtedly the best. This investigation on a mixed herd of British Holsteins and grade Short-Horns furnishes data of the value for the records of the first lactation in comparison with the yields of subsequent lactation. In all of this work the measure of the lactation used is what he designates as the "revised maximum," this term being defined as the maximum day yield of the lactation which is three times reached or exceeded. These results are considered largely for their strictly practical bearing. They are of little use to the American farmer in that he is accustomed to deal with records over a certain limit of time and not maximum productions. The constants derived by Gavin will be of a good

deal of interest for comparison data with that presented here as together they show the range of variation to be expected under the different conditions of England and the United States, a mixed herd and a pure bred herd, and a difference in the measure of the lactating capacity from lactation to lactation.

Any adequate analysis of this problem should include a study of the means and standard deviations of milk production for the different age groups into which the lactations are divided. The necessity for such analysis lies in the following fact. If it can be shown that the milk production of the earlier years in a cow's life has been used to select only high producing cows to remain in the herd at later years it follows that the correlations will be for this selected herd and not for the breed as a whole.

The analysis of the means and standard deviations for this data show that no such selection took place. From this it follows that the rise and fall of mean milk production with advancing age shown in the preceding bulletin is due strictly to the physiological changes brought about in the mammary functions of the cow by age. The general equation to this physiological change expresses the law by which it is governed in the same way that Minot, Pearson and others have expressed the similar law for the manner in which the metabolic functions producing growth changes with increasing age.

It further is established that the results to follow are free from any influence of such selection.

The Correlation of Eight Months Milk Production at a Given Age With the Eight Months Milk Production at Any Other Given Age.

For a firm foundation of our practical agriculture, particularly dairying, knowledge of the inter-relationships of the milk yield at one age in comparison with the milk yield of another age can scarcely be too exact. The existing practice is, as already pointed out, largely empirical in its nature often leading to questionable results. The reflection of the questionable nature of these practices is seen in the not uncommon practice of dairymen neglecting the records of the first lactation as a measure of the cow's possibilities for future milk production.

The correlations between the milk production of various lactations with one another has material importance as well as theoretical interest for these problems. If the correlation is high it is evident from the practical side that the culling of the herd through the use of dependable criteria will result in increase in the milk yield per cow within the herd and in the increase of profits to its owners. From the biological side, a high correlation means that the animals composing the herd innately differentiated (presumably due to their inherited complex) in their mammary capacities.

The determination of the correlations for these data are of especial interest for as previously shown in the earlier part of this paper, the data are of exceptional value in that; they are on a pure bred Jersey herd kept intact for many years; the lactation records for several lactations are recorded on a number of the animals; and the herd has been subject to no detectable culling based on the production of a given lactation. From these data there have been extracted lactation records to the number of 3178 pairs having a full eight months lactation free from any disease or sickness or other trouble known to influence the records. These records have been formed into twenty-eight correlation tables the most of which are of considerable size.

Table 1 gives the correlations and their probable errors for all ages into which the lactation records were divided. The vertical columns give the correlations of the age heading the column with the ages indicated at the left margin of the table. As will be noted the correlations necessary to give the complete set of correlation for any given age are repeated e. g. the correlation of 2 years with 3 years is $+0.5764 \pm .0332$ and appears in the 2 year column. The correlation of 3 years with 2 years will, of course, be the same ($0.5764 \pm .0332$) and is repeated in the three year column. In this manner a complete picture of the relationship of the lactations of the 2 year group with the other lactations of the other groups is given in the column.

The order of magnitude of these correlations is from $+0.7306$ for the correlation of 8 months milk productions during the ages 5 to 6 and 6 to 7 and $+0.2144$ for the correlation of the productions during the ages 4 to 5 and 10 and older. Such correlations indicate that the milk production of one lactation may be predicted with relatively little inaccuracy from the milk production of another lactation.

TABLE 1.

Coefficients of Correlation of Milk Production of a Given Age With the Milk Production of Another Given Age.

Age	2–3	3–4	4–5	5–6
2 to 3	----------	+0.5764±.0332	+0.5426±.0361	+0.5373±.0406
3 to 4	+0.5764±.0332	----------	+0.6296±.0335	+0.5479±.0395
4 to 5	+0.5426±.0361	+0.6296±.0335	----------	+0.5541±.0391
5 to 6	+0.5373±.0406	+0.5479±.0395	+0.5541±.0391	----------
6 to 7	+0.5500±.0426	+0.5305±.0452	+0.5624±.0421	+0.7306±.0284
7 to 8	+0.5815±.0468	+0.5394±.0483	+0.6328±.0380	+0.5667±.0403
8 to 10	+0.4938±.0488	+0.5376±.0465	+0.4154±.0503	+0.5405±.0397
10 and older	+0.5603±.0732	+0.6336±.0925	+0.2144±.0919	+0.5371±.0697

Age	6–7	7–8	8–10	10 and older
2 to 3	+0.5500±.0426	+0.5815±.0468	+0.4938±.0488	+0.5603±.0732
3 to 4	+0.5305±.0452	+0.5394±.0483	+0.5376±.0465	+0.6336±.0925
4 to 5	+0.5624±.0421	+0.6328±.0380	+0.4154±.0503	+0.2144±.0919
5 to 6	+0.7306±.0284	+0.5667±.0403	+0.5405±.0397	+0.5371±.0697
6 to 7	----------	+0.6515±.0349	+0.4800±.0427	+0.4578±.0666
7 to 8	+0.6515±.0349	----------	+0.5750±.0367	+0.3036±.0712
8 to 10	+0.4800±.0427	+0.5750±.0367	----------	+0.5113±.0448
10 and older	+0.4578±.0666	+0.3036±.0712	+0.5113±.0448	----------

The graph for the correlations, coefficients of the milk production of one lactation with the milk production of subsequent lactations of the same cows shows little deviation from a straight line. The values of these correlations range from +0.4938 ±.0488 to +0.5815±.0468. The values for the three year correlations with the other years range is somewhat higher +0.5305 ±.0452 to +0.6336±.0925. These correlations would be quite accurately described by a linear function. The values of the correlation of four year old's production with those of other years range from +0.2144±.0919 to +0.6328±.0380. On the whole these values are slightly lower than are those for other years. The values for the five year olds range from +0.5371 ±.0697 to +0.7306±.0284. These values are the highest in their range of any of the ages. The correlations for the six year productions with those of other ages range from 0.4578 ±.0666 to +0.7306±.0284. The correlations for the seven year productions range from 0.3036±.0712 to +0.6515±.0349. The correlations for the 8 and 9 year period range from +0.4154 ±.0503 to +0.5750±.0367 and the correlations for the produc-

tions at 10 years and older with those of the younger years range from $+0.2144 \pm .0919$ to $+0.6336 \pm .0925$. From this brief resume of the tabled results it is seen that all of the results have the plus sign and have a rather large value for data of this kind. The values of the coefficients are in general higher for the younger ages than they are for the older ages. This is a fortunate circumstance from a practical standpoint for the breeder is more desirous of selecting the animal to remain in the herd from their two year records than he is to select his animals at ten years old. The values of the correlations are fortunately such that a gain in accuracy results by predicting from the two year olds as over predictions at later ages.

From the practical side of culling the poor milkers out of the herd these results are highly satisfactory. The data are equally interesting when considered in their biological aspects. The correlation shows that the cows composing the herd are innately differentiated in their milk producing abilities. The plane of production once established the cow tends to maintain this relative plane from lactation to lactation. The value of the correlation indicates clearly that the mechanism behind this function works quite accurately.

From this point of view it is of a good deal of interest to compare the only other statistics available for cattle with those derived here. Gavin using his measure of the lactation, the "revised maximum," found the correlation between the milk productions of the various lactations "revised maximum." Table 2 is a copy of Gavin's table showing these correlations.

TABLE 2.

Lactation	r with max. R. M.	Probable Error
First	+.394	±0.031
Second	+.452	±0.030
Third	+.506	±0.028
Fourth	+.605	±0.024
Fifth	+.762	±0.016

This table shows in general a lower value for the correlations measuring the consistency of milking performance from lactation to lactation than is shown on our data. This may in part be due to the fact that Gavin's material was somewhat

heterogeneous including data from British Holstein and Short-Horns. In all events, the correlations confirm our general conclusions that milk production of one lactation is quite closely correlated with that of the other lactations. This reasoning transferred to the individuals of the race of dairy cattle, appears to prove beyond any shade of doubt that the individuals of the race are innately differentiated as regards the capacity for milk production.

Of the quantitative data on other species of practical interest perhaps the most complete is that of Harris and Blakeslee on the White Leghorn. In this work they determine the correlations between the monthly egg production and the other eleven months production of the same bird. The correlation for these monthly ovulations with the other eleven months ovulation take values ranging from $+0.240 \pm .033$ to $+0.573 \pm .023$. The range is there quite similar to those obtained in this study of milk secretion although lower in value. The knowledge of these sets of constants gives criteria for the fairly accurate prediction of the records that may be expected as a subsequent date in the life of these two extremely important economic species.

From these correlation coefficients in table 2 it is possible to form the straight line prediction of the milk yield of any age from the yield of any other age. As emphasized repeatedly in the various sections of this paper dealing with the separate subjects, the predictions may be criticized on the following grounds; that the mean milk yield rises with age in a line described by a logarithmic function; that the standard deviation of this milk yield rises in line described by a cubic parabola; and that the values of the correlation coefficients differ from the values of the correlation ratios by 2.42 times the probable error of $\eta^2 - r^2$. Such criticisms are recognized and admitted at once. It is believed that even admitting these there are a number of important points which may be elucidated by these equations.

The general equation for these regressions is given by

$$Y = (\text{Mean}_Y - \frac{\sigma Y}{\sigma y} \text{Mean } y) + rYy \frac{\sigma Y}{\sigma y} y$$

TABLE 3.

Regression Equations of the Milk Yield for Any Age from That of Any Lactation Record at Another Age.

AGE AT WHICH EXPECTED MILK YIELD IS DESIRED.

Age at which milk yield was made	2 years to 3 years	3 years to 4 years	4 years to 5 years	5 years to 6 years
	Regression Equation	Regression Equation	Regression Equation	Regression Equation
2 years to 3 years y_2	----------	$Y=1515.5+.7922y_2$	$Y=1447.4+.8591y_2$	$Y=1795.7+.8968y_2$
3 years to 4 years y_3	$Y=2130.0+.4194y_3$	----------	$Y=2013.7+.6500y_3$	$Y=2082.5+.6882y_3$
4 years to 5 years y_4	$Y=2391.2+.3427y_4$	$Y=1656.2+.5935y_4$	----------	$Y=2007.2+.6325y_4$
5 years to 6 years y_5	$Y=2394.4+.3219y_5$	$Y=2408.3+.4362y_5$	$Y=2513.3+.4855y_5$	----------
6 years to 7 years y_6	$Y=2456.2+.3018y_6$	$Y=2346.6+.4330y_6$	$Y=3092.2+.3652y_6$	$Y=1624.4+.6708y_6$
7 years to 8 years y_7	$Y=1995.3+.3955y_7$	$Y=2252.6+.4790y_7$	$Y=2345.0+.5149y_7$	$Y=2507.8+.5086y_7$
8 years to 10 years y_8	$Y=2570.8+.2927y_8$	$Y=2437.6+.4433y_8$	$Y=3367.9+.3298y_8$	$Y=2715.2+.4959y_8$
10 years and above y_{10}	$Y=2633.1+.3105y_{10}$	$Y=868.8+.8766y_{10}$	$Y=3952.6+.2190y_{10}$	$Y=2905.2+.5265y_{10}$

Age at which milk yield was made	6 years to 7 years	7 years to 8 years	8 years to 10 years	10 years and above
	Regression Equation	Regression Equation	Regression Equation	Regression Equation
2 years to 3 years y_2	$Y=1551.7+1.0023y_2$	$Y=1910.8+.8549y_2$	$Y=1710.8+.8329y_2$	$Y=717.0+1.0109y_2$
3 years to 4 years y_3	$Y=2578.2+.6500y_3$	$Y=2502.2+.6075y_3$	$Y=2036.3+.6519y_3$	$Y=2539.6+.4589y_3$
4 years to 5 years y_4	$Y=1158.8+.8662y_4$	$Y=1435.1+.7778y_4$	$Y=2500.7+.5233y_4$	$Y=3711.3+.2100y_4$
5 years to 6 years y_5	$Y=1332.7+.7958y_5$	$Y=2165.0+.6314y_5$	$Y=2087.7+.5890y_5$	$Y=1871.7+.5480y_5$
6 years to 7 years y_6	----------	$Y=1779.2+.6585y_6$	$Y=2493.0+.5019y_6$	$Y=2681.7+.4147y_6$
7 years to 8 years y_7	$Y=1960.8+.6445y_7$	----------	$Y=1573.3+.6720y_7$	$Y=3205.1+.3129y_7$
8 years to 10 years y_8	$Y=2989.5+.4591y_8$	$Y=2720.5+.4920y_8$	----------	$Y=2271.5+.5075y_8$
10 years and above y_{10}	$Y=2899.8+.5053y_{10}$	$Y=3772.8+.2946y_{10}$	$Y=2660.1+.5150y_{10}$	----------

As the milk production is given in pounds the second term of each of these equations gives the gain in expected milk yield for the given age, if one pound increase in actual production is made during the test. The calculation of an expected yield is, therefore a simple matter of direct substitution.

Thus for the dairyman with a herd of cows producing an amount of milk similar to this herd of Jerseys, suppose one of his cows produces 5000 pounds as a two year old, what would the six year old production be? In the 6 year to 7 year column on line with the 2 years to 3 years is given the equation necessary to solve the problem, $Y=1551.7+1.0023_{y2}$. The arithmetrical computation for each step is $1.0023 \times 5000=5011.5+1551.7$ 6563.2 the pounds of milk expected of the cow at six years. The repetition of this process for any milk production or age gives the desired probable milk yield.

Correlation of One Lactation Record With the Milk Yield for the First Five Lactations.

From a practical view point perhaps nothing is more important than a knowledge of the degree of accuracy with which the record of one lactation expresses what the milk yield over a number of lactations will be.

For this purpose a series of data including records of five lactations was chosen. Each of the cows whose records were selected began milking in the second year. The five lactations were consecutive and approximately a year apart depending on how long the previous lactations were continued. The lactation records for the five successive lactations were correlated with the total milk production for the five lactations. The correlation coefficients and other constants for these are given in table 4.

TABLE 4.

Age when lactation commenced	Mean Milk Production	Standard Deviation for the Milk Production	Coefficient of Variation for the Milk Production
2 years to 3 years	4159.1± 57.8	803.2± 40.8	19.31±1.00
3 years to 4 years	4840.9± 86.1	1197.9± 60.9	24.74±1.35
4 years to 5 years	5380.7± 78.8	1096.2± 55.7	20.37±1.06
5 years to 6 years	5568.2± 87.1	1211.2± 61.6	21.75±1.17
6 years to 7 years	5681.8± 91.4	1270.7± 64.6	22.36±1.17
Total of five lactations	25613.6±335.9	4672.0±237.5	18.24± .94

Age when lactation commenced	Correlation of Individual lactation records and five lactation total Production	Correlation Ratio of Individual lactation records and five lactation total Production	Regression Equations. 8 months lactation and five lactations total Production
2 years to 3 years	+0.7416±.0323	+0.7517±.0312	$Y_T=7671.9+4.3139y_2$
3 years to 4 years	.8418±.0209	.8856±.0155	$Y_T=9719.5+3.2833y_3$
4 years to 5 years	.8613±.0186	.8796±.0162	$Y_T=5861.4+3.6710y_4$
5 years to 6 years	.8250±.0230	.8561±.0192	$Y_T=7893.5+3.1824y_5$
6 years to 7 years	.8205±.0234	.8466±.0203	$Y_T=8471.9+3.0170y_6$
Total of five lactations			

The high correlation between the record of one lactation and the total production (first five lactation periods) is manifest. The correlations are so high as to lead to the conclusion that the record of one lactation in a cow's life serves to determine the records for the total production in the cow's life.

The comparison of the accuracy with which this control mechanism works with that of similar secretions on other species has a good deal of direct bearing on the subject. The only data available are for the egg of the domestic fowl.

Correlations obtained by Harris and Blakeslee for the successive monthly egg productions of White Leghorn pullets with their first annual production range from $+0.372 \pm .030$ to $0.695 \pm .018$ with an average of 0.556. The correlations of the successive yearly productions and the total of the first five lactations shown in table 4 range from $+0.7416 \pm .0323$ to $0.8613 \pm .0186$. The difference between these correlations is striking. In the proper calculation of this difference it must be remembered that the correlations for egg production is for the twelve month period where the production for the individual month correlation only contributes one-twelfth to the total annual egg production while that for the milk production contributes about one-fifth to the total production of the five lactations. The correlation would therefore be expected slightly larger for the milk production. This increased size of the milk correlations over the egg correlations is very small relative to the whole difference as the confirmatory results of table 1 shows. The correlations for the milk production of the successive lactations, therefore, represent in concrete terms that a greater reliance may be placed in the milk records of one lactation as measuring the cow's capacity than can be placed in the monthly egg records as measuring the hen's capacity for annual production. Such being the case, if we generalize this conclusion in its ultimate terms, the causative mechanism behind milk production works with greater fineness and precision than does the mechanism for egg production. Since this mechanism seems in its broadest sense to be of hereditary origin in the two cases, it follows that in the cow this hereditary complex is less influenced in its action by environment than is the action of the material stuffs of the fowl for egg production.

PRACTICAL ASPECT OF THE CORRELATIONS FOR MILK PRODUCTION OF ONE LACTATION RECORD WITH ANOTHER LACTATION RECORD.

The constants deduced in table 4 have a good deal of practical value to the dairyman and to the student of farm manage-

ment. To illustrate, suppose a herd which has 1000 two year olds who have just completed their first lactation is chosen at random. The manager of this herd will wish to know what animals to save for future lactations and the student of farm management desires to know what may be expected for the total production of the animals to enable him to determine the plane to which the herd should be culled for the greatest profit to the owner.

Perhaps one of the easiest ways to table the necessary information for its readiest uses is to have the summation of both the number of cows and their expected total production. This summation to be from both ends of the range of milk produced. The data for such a comparison are given in table 5.

If all the cows in this herd are kept to their sixth lactation the average production for each cow for the five lactations would be 25,070 pounds of milk. Noting the summed number of cows in column four if the 217 poorest producers are culled from the herd the cows left in the herd will produce on an average 26,408 pounds or an average 5,389 pounds more milk than the culled cows. Again if the dairyman decides to cull out 543 of the thousand animals the production of the 457 remaining will be 28,192 pounds or 5,747 pounds more than the culled cows on the average for the summed productions for the five lactations.

As the records dealt with in this paper are all for the first eight months of lactation it follows that most cows will extend beyond this limit and produce more milk. In using this table to determine what cows may be kept profitably, this fact should be kept in mind. If the dairyman has determined the complete cost of producing his milk a knowledge of the price he receives for it will allow him to determine at once from column three what cows he should keep in the herd.

In the bulletin following this, the relation of the butter-fat percentage to the age of the cow will be analyzed using the records for this herd.

TABLE 5.

Actual Milk Production of One Thousand Two Year Old Cows and the Expected Five Lactation Yield for Any Division of That Herd or Per Cow for Any Division.

Actual Milk Production	Cows producing given amount	Expected five Lactation Yield	Summed Number of cows Lowest to Highest Production	Expected summed 5 lactation yield for cows in herd lowest to highest production	Summed number of cows highest to lowest production	Expected summed 5 lactation yield for cows in herd Highest to lowest	Expected production per cow—Lowest to highest	Expected production per cow—Highest to lowest
1375 to 1625	1	14143	1	14,143	1000	25,069,737	14,143	25,070*
1625 to 1875	2	15221	3	41,355	999	25,050,000	14,822	25,076
1875 to 2125	5	16300	8	128,721	997	25,028,382	15,794	25,098
2125 to 2375	12	17378	20	335,173	992	24,941,016	16,734	25,146
2375 to 2625	23	18457	43	753,397	980	24,734,564	17,649	25,240
2625 to 2875	38	19535	81	1,498,071	957	24,316,340	18,538	25,401
2875 to 3125	57	20614	138	2,681,904	919	23,571,666	19,400	25,644
3125 to 3375	78	21692	217	4,381,681	862	22,387,833	20,229	25,979
3375 to 3625	98	22770	314	6,604,300	783	20,688,056	21,019	26,408
3625 to 3875	112	23849	426	9,266,303	686	18,465,437	21,761	26,926
3875 to 4125	118	24927	543	12,195,510	574	15,803,438	22,445	27,524
4125 to 4375	114	26006	657	15,161,471	457	12,874,227	23,063	28,192
4375 to 4625	102	27084	759	17,922,976	343	9,908,266	23,604	28,920
4625 to 4875	84	28163	843	20,281,602	241	7,146,761	24,056	29,698
4875 to 5125	63	29241	906	22,121,166	157	4,788,135	24,416	30,517
5125 to 5375	43	30320	949	23,422,180	94	2,948,571	24,683	31,371
5375 to 5625	26	31398	975	24,247,950	51	1,647,557	24,864	32,254
5625 to 5875	14	32477	989	24,711,391	25	821,787	24,974	33,163
5875 to 6125	7	33555	996	24,936,881	11	358,346	25,032	34,096
6125 to 6375	3	34634	999	25,029,352	4	132,856	25,057	35,054
6375 to 6625	1	35712	1000	25,069,737	1	40,385	25,070*	36,058

*It will be noted that this figure does not correspond exactly with that of table 4.

The Mathematical Handling of Breeding Data.

All investigations and inquiries that involve numbers require more or less mathematical handling. Where the data involved are few an arithmetical mean or average is all that is required. For instance in the chemical analysis of a fertilizer rarely more than two or at the outside three determinations are involved. Hence adding these together and dividing by the number of determinations gives the average. On the other hand in plant and animal breeding work where hundreds or even thousands of units of data are involved the handling involves not merely arithmetical but logarithmic methods also and other problems arise that can only be solved by the calculus.

These data that have to be handled in this complicated way and the results that can only be stated mathematically furnish the only sources for the answer to the questions that confront the practical animal and plant breeder. They must be stated in a mathematical form in order to present the results as they exist. The attempt to put them into everyday language impairs their accuracy of definition. The terms used are new and unusual. For the biometrical methods of handling these data are new. In time these will come to be as readily understood as are the terms used in feeding stuffs and fertilizer analyses.

In its publications of the results of biological investigations the Maine Agricultural Experiment Station is embarrassed by just how far the steps in handling the data upon which the conclusions rest should be printed in the papers designed primarily for the men who are at the fore in the practical agriculture of the State. The bulletins of the Maine Agricultural Experiment Station give in black type at the beginning the conclusions arrived at in the publication. The text gives some of the more obvious and more readily comprehended steps in the investigation. The papers sent to the scientific journals go into the mathematical handling in much more detail.

With the hope of making the matter of the bulletin clear a sort of dictionary of the terms employed has been prepared and will gladly be sent on request to the undersigned.

Chas. D. Woods, Director
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